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Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

REMARKS / ARGUMENTS

In response to the first office action of May 1, 2006, Applicants have amended claim 1 and presented remarks below to resolve concerns raised by the Examiner. Reconsideration and allowance of the specification and pending, amended claims are respectfully requested.

I. Invention Overview

The invention is a vacuum fuel cell procedure and system for starting up a fuel cell by applying a vacuum to an anode flow field and then using a rapid fuel purge of the anode flow field to minimize corrosion of a carbon catalyst support layer by a reverse current mechanism produced by movement of a fuel-air front through the anode flow field. A vacuum source applies a vacuum to the anode flow field while the fuel cell is shut down and while a fuel inlet valve and a fuel exhaust valve are closed. The resulting vacuum within the anode flow field produces a rapid purge of the fuel through the anode flow field upon start up, and the vacuum may also remove essentially all of the air within the anode flow field to virtually eliminate movement of the fuel-air front, thereby minimizing any resulting corrosion.

II. Response to Office Action

In the May 1, 2006 office action, the Examiner has rejected

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

BEST AVAILABLE COPY

all pending claims. This response will address the concerns of the examiner in the order in which they appear within the office action.

First, in Section 1, the Examiner has rejected claims 1 - 7 under 35 U.S.C. 103(a) as being unpatentable over U.S. published patent application no. 2002/ 0076583 to Reiser et al. in view of U.S. Patent no. 6,926,981 to Voss, and in further view of U.S. Patent No. 6,391,485 to Perry. The Examiner has asserted, in essence, that Reiser et al. shows all of independent claim 1 except "the procedure comprising the step of applying a vacuum to the anode flow field." The Examiner urged that Voss shows "withdrawing the contents of the portion of the fuel cell stack by operation of a vacuum pump... to reduce or eliminate leakage of fuel from the fuel cell to surrounding environment." The Examiner then concluded that "it would have been obvious to one having ordinary skill in the art at the time applicants' invention was made to provide the step of applying a vacuum to the anode field in order to reduce or eliminate leakage of fuel from the fuel cell to the surrounding environment as taught by Voss." (Office action, at section 1 page 3.)

Applicants insist the Examiner's conclusion with respect to the rejection of independent claim 1 is wrong for two separate reasons.

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

FIRST, THE PRIOR ART REFERENCES FAIL TO TEACH OR SUGGEST ALL LIMITATIONS OF INDEPENDENT CLAIM 1, AS AMENDED.

"To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art." (Manual of Patent Examining Procedure ("MPEP"), Sec. 2143.03.) By the present amendment to independent claim 1, applicants have added the structure and function of a fuel inlet valve and a fuel outlet valve. Antecedent bases for that amendment are found in the specification at page 9, line 2 - 33, and in claim 8 lines 20 - 32.

It is stressed that a primary goal of Applicants' invention is to remove oxygen from the anode flow field prior to the introduction of the hydrogen fuel to the flow field. For example, page 3, line 1, in the background section of the specification, a major problem is characterized as: "the presence of any oxygen within an anode flow field during start up results in a reverse current leading to unacceptable, localized electrode potentials and corrosion of catalysts and catalyst support materials." Applicants' invention in this application solves that problem by applying a vacuum to the anode flow field while the fuel cell is shut down and prior to the admission of hydrogen fuel into the anode flow field. The vacuum within the anode flow field "decreases an amount of time necessary for the hydrogen fuel to pass anode flow field." (Specification, at page 4, lines 33-35.) "More importantly, the vacuum may remove virtually all of the air within the anode

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

and/or cathode flow fields. Removal of the air from the anode flow field essentially eliminates the reverse current mechanism that creates the corrosion." (Specification, page 5, line 2-6.) This key value of Applicants' is recited at the beginning, as quoted above, and at the conclusion of the detailed description of the invention. "More importantly, if the vacuum is at a sufficient level to remove virtually all of the air within the anode flow field 38 prior to introduction of the hydrogen fuel, then there is virtually no fuel-air front moving through the anode flow field 38, which even further minimizes any oxidation or corrosion of the carbon in the catalyst layers 22, 26." (Specification, page 10, lines 29 - 35.)

By the present amendment to claim 1 of adding the structure of the fuel inlet and outlet valves, and the steps of first closing the fuel inlet and outlet valves, then "applying a vacuum to anode flow field" and then opening the fuel inlet and outlet valves prior to delivering fuel to the anode flow field, Applicants have emphasized claim limitations that both achieve a primary goal of the invention, and that are neither shown nor suggested in the "vacuum pump" of Voss.

The Examiner has indicated that Voss shows use of a "vacuum pump" at Col. 5, lines 24-29. That section of Voss states: "The purging step can comprise withdrawing the gaseous and/or liquid contents of the portion of the fuel cell stack through the fuel cell inlet or the fuel stream outlet, and/or withdrawing the contents of the portion of the fuel cell stack

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

by operation of a vacuum pump." It is pointed out that the "purging step" described in Voss seeks to attain a totally different goal than removing oxygen from an anode flow field. Instead, the "purging step" in Voss is for removing a "diluent", which is essentially a non-fuel component within the fuel stream. "The concentration of fuel, in turn depends on the concentration of diluent that has accumulated, since the presence of diluents dilutes the concentration of fuel in the fuel stream present at the monitoring cell." (Voss at Col. 7, lines 13 - 17.)

To achieve this goal of removing diluents, the "purging step" of Voss is applied while the fuel cell is operating. This is demonstrated in the detailed description of Voss at Col. 8, line 19 - 29.

"In another method of purging, the controller 10 sends a signal to a vacuum pump (not shown in FIG. 1) which, when operated, withdraws the contents of the fuel stream in the fuel cell stack, thereby purging it of diluent. If a vacuum pump is used, the pressure of the fuel stream need not be adjusted. In such a method, the controller 10 need not control the pressure of the fuel stream; instead the pressure of the fuel stream may be passively set with respect to ambient pressure, for example, by the use of a conventional gas regulator." (Emphasis added.)

BEST AVAILABLE COPY

Appl. No. 10/749,971

Amendt. Dated August 15, 2006

Reply to Office Action of May 1, 2006

Further proof that the "vacuum pump" of Voss is only applied while a fuel stream is passing through the fuel cell is found in the next paragraph of Voss which states:

"In either of the above methods, the controller 10 may also send a signal to an exhaust valve 9, so that the fuel passage of the fuel cell stack is temporarily open-ended. As the diluent(s) exhaust, their concentration at the monitoring cell 12 decreases and the cell voltage of the monitoring cell 12 increases. Once the voltage of the monitoring cell 12 rises above an upper threshold voltage limit, as observed by the controller 10, a second output signal is sent to the pressure control mechanism 2, which returns the fuel stream pressure to lower than the pressure of the surrounding environment. The controller 10 can send a signal to instruct the exhaust valve 9 to close. Once the exhaust valve 9 is closed, diluent begins accumulating, and cell voltage of the monitoring cell 12 again decreases until it reaches the lower threshold voltage limit and the cycle repeats itself."

(Voss, at Col. 4, lines 29 - 44. Emphasis added.)

In essence, Voss describes a fuel cell system wherein diluents accumulate within a typically "dead-ended" fuel flow path, and the system routinely "purges" the contaminant diluents from the fuel flow path while the fuel cell system is operating. One method of purging requires opening of a fuel outlet and

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

increasing pressure to purge the fuel out of the fuel flow path. An alternative method of the Voss "purging step" discloses an un-illustrated "vacuum pump" that aids in the removal of diluents while the controller monitors removal of the diluents through changes to the operating cell voltage. Nothing in Voss shows or suggests application of a vacuum to a component of a fuel cell through which passage of a fuel stream is prohibited. If any step or structure of Voss were utilized to prohibit passage of a fuel stream during application of a vacuum to the fuel cell, the controller of Voss could not monitor cell voltage during the "purging step", as required by Voss. Similarly, if the vacuum pump of Voss were to be applied as in amended claim 1 of the present application to an anode flow field through which the fuel stream could not pass, the goal of Voss of removing contaminants from a fuel stream would be unobtainable.

Therefore, Voss neither shows nor suggests all of the claimed limitations of independent claim 1, as now amended. Further, nothing in Reiser et al. shows or suggests the steps of amended claim 1 of closing the fuel inlet and outlet valves of an anode flow field to restrict passages of a fuel stream, then applying a vacuum to the anode flow field, and then opening inlet and outlet fuel valves to permit passage of a fuel stream. Accordingly it is respectfully requested that Voss and Reiser et al. be removed as references.

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

SECOND, THERE IS NO SUGGESTION OR MOTIVATION TO COMBINE
REISER et al. AND VOSS

"If [a] proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification." (MPEP, Sec. 2143.01 V.) In urging that the elements of Reiser et al. could be modified by the addition of the "vacuum pump" of Voss, the Examiner concluded that "it would have been obvious to one of ordinary skill in the art to provide the step of applying a vacuum to the anode field in order to reduce or eliminate leakage of fuel from the fuel cell to the surrounding environment as taught by Voss." (Office Action at section 1, page 3.) Applicants urge that there is no motivation or suggestion to make such an addition of the use of the vacuum pump of Voss, as described in Voss, to Reiser et al, because such a modification would be detrimental to the intended purpose of Reiser et al.

Reiser et al. recites its intended purpose in many locations, and it is essentially to reduce the time it takes to move a hydrogen/air front through a fuel cell flow field upon shut down of the fuel cell, as well as upon start up of the fuel cell. The title of Reiser et al. and claim 1 indicate the primary focus is upon shut down of the fuel cell. Reiser et al. describes the method of moving the hydrogen/air front rapidly through the fuel upon shut down as the "blower 152 blows this air directly into and through the channels of the anode flow

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

field, quickly displacing any fuel remaining therein." (Reiser et al. at Para [0031].)

More specifically, in discussing both shut down and start up of a fuel cell, Reiser et al. states: "Similarly, during start-up, it is preferred to displace the air within the anode flow field with fuel as quickly as possible. In either case the displacement should occur in less than about 1.0 seconds, and preferably less than 0.2 seconds. For long life applications with a high number of start-stop cycles, such as for automotive applications, it is most preferable to purge the fuel from the anode flow field at shut-down and to purge the air from the anode flow field at start-up in less than 0.05 seconds." (Reiser et al. at Para. [0037]) Reiser achieves this extremely rapid displacement through "[b]lowers and other devices used to move the gases through the system [that] may easily be selected to achieve the desired speed with which the hydrogen/air front is to move through the cell and thus purge the cell of undesired gases." (Id.)

In the "Start-up Procedure" of Reiser et al. that commences at paragraph no. [0035], it is pointed out that the "purging" of the undesired hydrogen/gas front is achieved not by first removing an undesirable oxidant gas as in amended claim 1 of the present application. Instead, the "purge" (Reiser et al., Title) is accomplished by directing high pressure hydrogen through the anode flow field to displace the air within the shut down fuel cell. "The hydrogen flow pushes the air out of the

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

anode flow field." (Reiser et al. at Para. [0036]) This is emphasized again in Para. [0038]: "the rapid air purge of fuel from the anode flow field at shut-down and the rapid hydrogen purge of air from the anode flow field upon start-up significantly increases cell life by reducing cumulative cell performance losses resulting from repeated shut-downs and start-ups." (It is pointed out that the Examiner stated in Section 1, page 2 in describing Reiser et al. that: "the procedure comprising the steps of purging the air from the anode flow field..., then delivering a continuous flow of hydrogen fuel into the anode flow field..." actually mischaracterized Reiser et al. As pointed out above, "purging the air" from the anode flow field of Reiser et al. is done by the flow of hydrogen that "pushes the air out of the anode flow field". In Reiser et al. the "purging of the air" is not a separate step from the delivering of a continuous flow of hydrogen through the anode flow field. The delivery of the hydrogen pushes or purges the air out of the fuel cell. In contrast, in the present Application, first flow of hydrogen is prohibited by closing the fuel inlet and outlet valves; then the separate step of removing air from the anode flow field takes place; and then the valves are re-opened to permit flow of the hydrogen fuel.)

Again, Reiser et al. repeatedly stresses that a heightened speed of removal of the air from the anode flow field upon a fuel cell start up is a primary goal that can be achieved by the apparatus and method of Reiser et al. including use of "blowers", "pressurized hydrogen", and "other devices used to

BEST AVAILABLE COPY

Appl. No. 10/749,971

Amendt. Dated August 15, 2006

Reply to Office Action of May 1, 2006

move the gases through the system." (Reiser et al. at Paras. [0036] - [0038].)

As described in detail above, the "vacuum pump" of Voss is only described as being used when a fuel stream is passing into the fuel cell. "[In use of the vacuum pump method of purging diluents out of the fuel stream] the controller 10 may also send a signal to an exhaust valve 9, so that the fuel passage of the fuel cell stack is temporarily open-ended. As the diluent(s) exhaust, their concentration at the monitoring cell 12 decreases and the cell voltage of the monitoring cell 12 increases. Once the voltage of the monitoring cell 12 rises above an upper threshold voltage limit, as observed by the controller 10, a second output signal is sent to the pressure control mechanism 2, which returns the fuel stream pressure to lower than the pressure of the surrounding environment. The controller 10 can send a signal to instruct the exhaust valve 9 to close. Once the exhaust valve 9 is closed, diluent begins accumulating, and cell voltage of the monitoring cell 12 again decreases until it reaches the lower threshold voltage limit and the cycle repeats itself." (Voss, at Col. 4, lines 29 - 44.)

Application of such a vacuum pump to the moving fuel stream of Reiser et al. to purge it of diluents while the fuel stream is flowing through the fuel cell would necessarily reduce by the vacuum force the high pressure of the fuel stream. That would necessarily slow down the movement of the fuel through the fuel cell, which would increase the duration of transit of the

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Appl. No. 10/749,971

Amendt. Dated August 15, 2006

Reply to Office Action of May 1, 2006

hydrogen/air front through the anode flow field. Again, application of the Voss vacuum pump (as described in Voss) to the fuel stream of Reiser et al. would necessarily decrease pressure of the fuel stream and hence work against the "blowers" or "pressurized hydrogen" of Reiser et al., thereby slowing down flow of the hydrogen as it purges the air out of the anode flow field.

Because use of the Voss vacuum pump as described in Voss would slow down the movement of the hydrogen/air front through the anode flow field, the resulting modified Reiser et al. fuel cell would thus be unsatisfactory for its described intended purpose of increasing the movement of the hydrogen/fuel front through the anode flow field. Therefore, it would not be obvious to one of ordinary skill in the art to provide the step of applying a vacuum to the fuel stream passing through the anode flow field of Reiser because it would make Reiser et al. unsatisfactory for its intended purpose. Consequently, it is requested that the Examiner remove her rejection of claim 1 as amended for the separate reason that there is no suggestion or teaching to modify Reiser et al. by adding to it the applying a vacuum step of Voss.

Additionally, the Examiner stated that: "it would have been obvious to one of ordinary skill in the art to provide the step of applying a vacuum to the anode field in order to reduce or eliminate leakage of fuel from the fuel cell to the surrounding environment as taught by Voss." (Office Action at section 1,

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

page 3.) It is respectfully pointed out that the Voss does not teach use of its "vacuum pump" to apply a vacuum to the anode flow field to "eliminate leakage or fuel from the fuel cell". As described above, the "vacuum pump" of Voss is used to extract contaminant diluents from a moving fuel stream. The mechanism and methods of Voss that maintain a sub-ambient pressure to minimize leakage are described as follows: "The pressure at which the fuel stream is supplied to the fuel cell stack 1 is controlled by the pressure control mechanism 2. Suitable pressure control mechanisms include adjustable valves, and pressure regulators. In the present embodiment, the pressure control mechanism 2 has at least two controllable settings: a lower pressure setting corresponding to a pressure below the expected pressure of the surrounding environment, and a higher pressure setting corresponding to a pressure above the expected pressure of the surrounding environment." (Voss, at Col. 6, lines 44 - 54.)

If a person skilled in the art sought to modify Reiser et al. to minimize leakage of fuel, the person would not use the vacuum pump and/or application of a vacuum method of Voss because Voss does not teach that such an apparatus and/or method minimizes leakage. In fact, Voss describes opening of a fuel exhaust outlet during application of the purging methods, thereby increasing a probability of fuel leakage. "In either of the above [purging] methods, the controller 10 may also send a signal to an exhaust valve 9, so that the fuel passage of the fuel cell stack is temporarily open-ended." (Voss at Col. 8,

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

lines 29 - 32.) Therefore, for this separate reason, it is urged that there is no motivation or suggestion in Voss or Reiser et al. to modify Reiser et al. with the vacuum pump and application of a vacuum of Voss.

Next, the Examiner rejected claims 2 - 7 on the basis of varying prior art references. However, claims 2 - 7 depend from independent claim 1, and if "an independent claim is allowable under 35 USC 103, then any claim depending therefrom is nonobvious." (MPEP Sec. 2143.03) Consequently, because Applicants urge that independent claim 1 as now amended should be allowable for the reasons presented above, it is requested that the Examiner remove her rejections of claim 2 - 7.

Next, at section 2, page 6 of the May 1, 2006 office action, the Examiner has rejected claims 8 - 11 under 35 U.S.C. 103(a) as being unpatentable over Reiser et al. in view of Voss and in further view of Perry. Claims 8 - 11 include only one independent claim, claim 8. The Examiner rejected independent claim 8 by asserting essentially that Reiser et al. shows all of the elements of claim 8 except an oxidant exhaust valve secured in fluid communication with the cathode flow field and a vacuum source means secured in fluid communication with the anode flow field. The Examiner concluded it would have been obvious to one having ordinary skill in the art at the time the invention was made to provide Reiser et al. with a vacuum to the anode flow field in order to reduce or eliminate leakage of fuel from the fuel cell to the surrounding as taught by Voss. The Examiner

BEST AVAILABLE COPY

Appl. No. 10/749, 971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

also added that an oxidant exhaust valve is taught by Perry and that it would also have been obvious to add to Reiser et al. the oxidant outlet valve of Perry.

Independent claim 8, at section c requires "a vacuum source means (90) secured in fluid communication with the anode flow field (38) for selectively applying a vacuum to the anode flow field (38) when the fuel inlet valve (70) and fuel exhaust valve (74) are closed to prohibit flow of the fuel through the anode flow field (38)." The undersigned reiterates here by reference to the argument and discussion presented above that the "vacuum pump" of Voss applies a vacuum to a flowing fuel stream to remove contaminant diluents from that stream while the stream is flowing through the fuel cell. Nothing in Voss or Reiser et al. shows or suggests a vacuum source means secured to the anode flow field so that it selectively applies a vacuum to the anode flow field when the fuel inlet and outlet valves are closed to prohibit flow of the fuel stream through the anode flow field.

Therefore, all of the claimed limitations of independent claim 8 are not shown by the vacuum pump of Voss, or by the above-described rapid hydrogen purge of air out of the anode flow field of Reiser et al. If the vacuum pump of Voss included the limitations of claim 8 to apply a vacuum to the anode flow field when the fuel inlet and outlet valves are closed, the vacuum pump of Voss could not remove the contaminant diluents from the fuel stream. Therefore, it is respectfully requested that the Examiner remove her rejection of independent claim 8

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

because the cited prior art references of Voss and Reiser et al. fail to show all of the limitations of independent claim 8.

Additionally, it is urged that it would not be obvious to "provide Reiser et al. with a vacuum to the anode flow field in order to reduce or eliminate leakage of fuel from the fuel cell...." (Office Action at sec. 2, page 7.) As recited above, adding the vacuum pump of Voss, as described by Voss, would reduce the pressure of the fuel stream passing through the anode flow field, which would frustrate the primary purpose of Reiser et al., thereby making Reiser et al. unsatisfactory for its intended purposes. Moreover, Voss does not teach that the vacuum pump and/or application of a vacuum can be used to reduce or eliminate leakage of fuel from the fuel cell, as discussed above. For these separate reasons, it is respectfully requested that the Examiner remove her rejection of independent claim 8.

The Examiner next rejected claims 9 - 11 on various prior art references. However, as urged above, because it is believed that independent claim 8 should be allowable, it is also urged that claims 9 - 11 that depend from claim 8 should also be allowable because they simply narrow with additional limitations independent claim 8. (See MPEP, sec. 2143.03.) Therefore, it respectfully requested that the rejections of dependent claims 9 - 11 be removed.

BEST AVAILABLE COPY

Appl. No. 10/749,971
Amendt. Dated August 15, 2006
Reply to Office Action of May 1, 2006

III. Conclusion

By the present amendment to independent claim 1, and by the discussion presented above it is respectfully urged that all of the Examiner's concerns raised in her May 1, 2006 first office action have been resolved. Accordingly, it is respectfully requested that the Examiner remove the rejections of the pending claims, and issue a Notice of Allowance.

Date: 8/15/06

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